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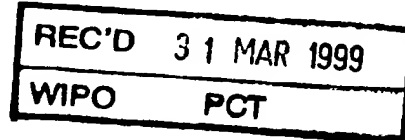
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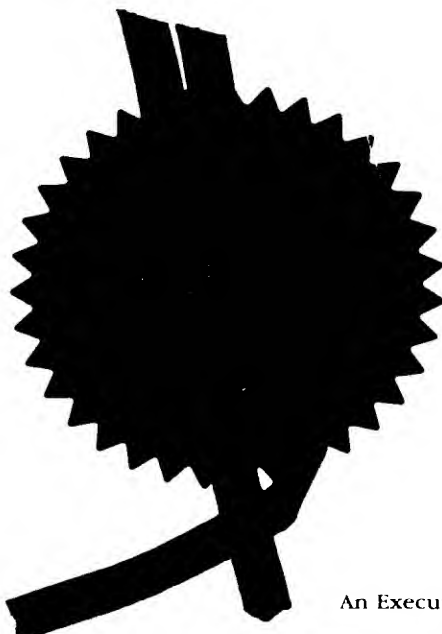


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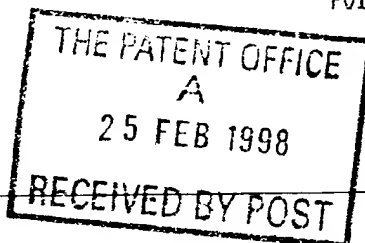
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1. Your reference

15251 LgCm

2. Patent application number
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9803817.7

25 FEB 1998

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

AEA Technology plc
329 Harwell
Didcot, Oxfordshire, OX11 0RA
United Kingdom

Patents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

England and Wales
069 69372001.

4. Title of the invention

A component for gas treatment

5. Name of your agent (*if you have one*)

Marcus John LOFTING

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

AEA Technology plc
Patents Department, 329 Harwell
Didcot, Oxfordshire, OX11 0RA

Patents ADP number (*if you know it*)

0729 8474001.

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Country

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Number of earlier application

Date of filing
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- a) any applicant named in part 3 is not an inventor, or
 - b) there is an inventor who is not named as an applicant, or
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Description	10
Claim(s)	3
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Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

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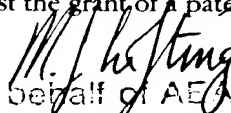
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Any other documents
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11. I/We request the grant of a patent on the basis of this application.

Signature



Date

23.2.98

M.J. LOFTING (On behalf of AEA Technology plc
by virtue of a Power of Attorney dated 26th March 1996)

12. Name and daytime telephone number of person to contact in the United Kingdom

01235 432037

Mrs P A Stewart

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A component for gas treatment

The present invention relates to a component for the treatment of gases, and in particular to a component for exposing gas to a non-thermal plasma, desirably in the presence of a catalyst. More specifically, the invention relates to a component incorporated in a reactor for the reduction of polluting components such as carbonaceous and nitrogenous combustion products emitted in the exhaust of internal combustion engines.

One of the major problems associated with the development and use of internal combustion engines is the noxious exhaust emissions from such engines. Two of the most deleterious materials, particularly in the case of diesel engines, are particulate matter (primarily carbon) and oxides of nitrogen (NO_x). Increasingly severe emission control regulations are forcing internal combustion engine and vehicle manufacturers to find more efficient ways of removing these materials in particular from internal combustion engine exhaust emissions. Unfortunately, in practice, it is found that techniques which improve the situation in relation to one of the above components of internal combustion engine exhaust emissions tend to worsen the situation in relation to the other. Even so, a variety of systems for trapping particulate emissions from internal combustion engine exhausts have been investigated, particularly in relation to making such particulate emission traps capable of being regenerated when they have become saturated with particulate material.

Examples of such diesel exhaust particulate filters are to be found in European patent application EP 0 010 384; US patents 4,505,107; 4,485,622; 4,427,418; and 4,276,066; EP 0 244 061; EP 0 112 634 and EP 0 132 166.

In all the above cases, the particulate matter is removed from diesel exhaust gases by a simple physical trapping of particulate matter in the interstices of a porous, usually ceramic, filter body, which is then
5 regenerated by heating the filter body to a temperature at which the trapped diesel exhaust particulates are burnt off. In most cases the filter body is monolithic, although EP 0 010 384 does mention the use of ceramic beads, wire meshes or metal screens as well. US patent
10 4,427,418 discloses the use of ceramic coated wire or ceramic fibres.

GB patent 2,274,3412 discloses a method and apparatus for removing particulate and other pollutants
15 from internal combustion engine exhaust gases, in which the exhaust gases are passed through a bed of charged pellets of material, preferably ferroelectric, having high dielectric constant (that is of the order of at least 1,000). In addition to removing particulates by
20 oxidation, especially electric discharge assisted oxidation, there is disclosed the reduction of NO_x gases to nitrogen, by the use of pellets adapted to catalyse the NO_x reduction as exemplified by the use of barium titanate as the ferroelectric material for the pellets.

25 The use of a reactor comprising a bed of beads of spherical, pellet, chip or other suitable form presents a problem, particularly for motor vehicles, in that the beads tend to wear or break up under the attrition to which they are subjected in use. Whilst monoliths of
30 foam or honeycomb configuration can be adopted, we have found satisfactory formation of a non-thermal plasma is difficult to achieve with known forms of these configurations.

35

It is an object of the present invention to provide a gas permeable component of dielectric material, which may be, or may be combined with, a catalytic material, for the treatment of gas, in a form which can be extruded
5 or otherwise formed into a monolithic structure, and which will effectively support the formation of a non-thermal plasma when subjected to an electric potential.

The invention provides, in one of its aspects, a
10 component for use in a gas treatment device, which component comprises dielectric material having apertures extending therethrough in a direction of gas flow through the component when in use, the apertures having a re-entrant configuration in cross-section and being such
15 that there is interconnection through dielectric material of those regions of dielectric material which define opposite sides of the narrowest part of the apertures as measured in at least one direction transverse to the said direction of gas flow, whereby when an electric potential
20 is applied across the component in the said transverse direction, or one of the said transverse directions, the voltage drop across the said narrowest part of the apertures is greater than the voltage drop thereacross would be if the aperture were filled with the dielectric
25 material.

For the purpose of providing the electric potential, a pair of electrodes is positioned one on one side and the other on the other side of the component so as to be
30 spaced apart from one another in the said transverse direction, or one of the said transverse directions.

In one arrangement according to the invention, the apertures are shaped to provide interconnection through
35 dielectric material of those regions of dielectric material which define opposite sides of the narrowest

part of the apertures as measured in two mutually
orthogonal directions transverse to the said direction of
gas flow, a first pair of electrodes is positioned one on
one side and the other on the other side of the component
5 so as to be spaced apart from one another in one said
transverse direction, and a second pair of electrodes is
positioned one on one side and the other on the other
side of the component so as to be spaced apart from one
another in the other, orthogonal, transverse direction.

10

The apertures are such as to promote formation of a
non-thermal plasma therein when the component is in use
and an electric potential is applied across the electrode
pair or pairs. For this purpose, for example, each
15 aperture is shaped in cross-section to taper on both or
all sides towards the said narrowest part of the
aperture, thereby to encourage transfer of electrical
discharge from the said narrowest part into the tapered
parts of the apertures.

20

Preferably the dielectric material is chosen to have
in the presence of an electrical discharge a catalytic
action in the reduction of nitrogenous oxides.

25

Preferably the dielectric material is a barium
titanate containing material.

The invention provides, in another of its aspects, a
reactor for reducing pollution from exhaust emissions
30 from an internal combustion engine, comprising a reactor
chamber adapted to form part of an internal combustion
engine exhaust system, the reactor chamber including a
component as aforesaid, through which component exhaust
gases are constrained to pass.

35

Specific constructions of component and reactor embodying the invention will now be described by way of example and with reference to the drawings filed herewith, in which:

5

Figure 1 is a perspective view of part of a component,

Figure 2 is a perspective view of part of another
10 component,

Figures 3, and 4, are diagrammatic representations of alternative cross-sectional shapes for the component, and
15

Figure 5 is a diagrammatical representation of a reactor incorporating a component according to the invention.

20 Figure 1 shows a component 10 which can be formed by extrusion from a dielectric material 11. Our preferred material is one containing barium titanate which, for extrusion purposes, may be fabricated from a barium titanate powder together with a binder of silica or a
25 silicon and titanium containing gel (which may be referred to as a silico-titanate gel).

As may be seen from Figure 1, the extrusion has the form of a series of parallel plates 12 between which, and
30 integral with which, is a matrix of rods 13 of generally rhombus shape in cross-section extending parallel with one another between the plates 12 along the length of the component 10.

35 The series of rods 13 between each pair of plates 12 provides a corresponding series of apertures 14 extending

along the length of the component 10 and having a shape in cross-section like that of a stylised bow tie.

Electrodes (not shown) positioned on the respective
5 two sides of the component 10 perpendicular to the plane of the plates 12 enable an electric potential to be applied to the component in a direction parallel with the plates 12 and transverse to the length of the apertures 14.

10

The re-entrant shape of the apertures 14 in cross-section has the effect that voltage drop derived from the charged dielectric material is concentrated in the region where the space between one rod 13 and its adjacent rod
15 is narrowest. This configuration has the effect of promoting the formation of non-thermal plasma in these narrow spaces. However, it is a feature of plasma formed in this way that it tends to expand and travel along outwardly tapering spaces which communicate with the
20 narrow space where plasma tends to be initiated. The shape of the apertures 14 is thus conducive to the formation of plasma which fills the entire void space of the component 10.

25 A feature of the configuration shown in Figure 1 is that the plates 12 provide a continuous dielectric path between the electrodes and between each such path there is a series of discharge gaps provided by the narrowest part of the apertures 14, the discharge gaps being
30 aligned to be parallel with the electric field set up between the electrodes.

Figure 2 illustrates another configuration in which component 15 can be formed by extrusion. Again, the
35 configuration is based upon an array of generally rhombus shaped rods 16,17. Alternate rows and columns of the

rods 16, 17 are joined at their apices by cruciform regions 18. The intervening rows and columns provide a series of discharge gaps 19. The rods 16, 17 are so shaped that the narrow spaces between adjacent rods which communicate with the discharge gaps 19 are tapered, with the narrowest region of the taper at the gaps 19. As explained above, this promotes the transfer of plasma formed in the discharge gaps 19 along the tapered spaces. It will be seen that adjacent each aligned row of discharge gaps 19 is an aligned row of interconnected rods 16. Similarly, adjacent to each aligned column of discharge gaps 19 is an aligned column of interconnected rods 17.

Electrodes (not shown) covering respectively the sides 21 and 22 of the component 15 enable an electrical potential to be applied across the component 15. By virtue of the juxtaposition of interconnected rods 16 in one row and cross connected rods 17 with intervening discharge gaps 19 in the adjacent row, application of an appropriate electrical potential in this way leads to the generation of plasma discharge in the gaps 19 and expansion of the plasma into the tapering spaces to fill the entire void structure of the component 15.

It will be apparent from the symmetry of the component shown in Figure 2, that electrodes (not shown) may be positioned to cover the sides 23 and 24 respectively so as to enable an electrical potential to be applied parallel with the columns of rods 16, 17. Provided there is an appropriate insulating gap between electrodes on the adjacent sides which may at any instant be at a different potential, electrical excitation may be applied to all four sides.

It will be appreciated that controlled arrays of discharge gaps between regions of dielectric material interconnected to concentrate potential drop across the discharge gaps can be achieved with a variety of
5 different configurations of extruded matrix. Figure 3 shows a variant of the Figure 2 configuration, similar components bearing the same reference numerals distinguished by the suffix "a". Figure 4 shows a
10 variant of the Figure 1 configuration, based upon cylindrical rods. The reference numerals used in Figure 4 correspond with those of Figure 1, distinguished by the suffix "a".

Figure 5 shows diagrammatically in cross-section a
15 component 25 comprising an extruded monolith having a configuration (chosen as discussed further below) as shown in one of the Figures 1 to 4 and incorporated in a plasma reactor for the purification of internal combustion engine exhaust emissions.

20

The component 25 is mounted within a cylindrical stainless steel chamber 26 which is arranged to be connected to an earthing point at 27 and which has an inlet nozzle 28 by means of which it can be connected to
25 the exhaust system of an internal combustion engine, and a similar outlet nozzle 29. Exhaust gas flows as indicated by the arrows A axially through the apertures of the component 25.

30 Because of the cylindrical geometry, it is necessary for the extruded monolith component 25 to have a symmetrical configuration such as that of Figure 2 cut or shaped into a cylinder with an axial bore 31. The axial bore 31 is closed at each end to ensure all gas flow is
35 through the apertures of the monolith component 25. An outer electrode is provided either by the chamber 26

itself or by a cylindrical metallic sheath on the component 25 and in electrical contact with the chamber 26. An inner electrode 32 is provided in the form of a cylindrical lining for the bore 31. The electrode 32 is
5 connected via a high tension lead-through 10 to a source 9 of electrical potential sufficient to excite a plasma in the exhaust gases in the void spaces within the component 25. A convenient potential for this purpose is a potential of about 10 kV to 30 kV, which may be a
10 pulsed direct potential or a continuously varying alternating potential, or may be an interrupted continuous direct potential. Typically we employ a potential of 20 kV per 30 mm of bed depth.

15 In a modified arrangement, in which any of the configurations of Figure 1,2,3, or 4 may be employed, the chamber 26 and component 25 are rectangular in cross section. For this configuration, it is not necessary to have a central bore corresponding to the bore 31.
20 Electrodes may be positioned on opposed sides of the component 25, but in this case it is necessary to provide electrical insulation between the high voltage electrode and the chamber 26. For this reason, it may be preferable to provide the high voltage electrode as a
25 sheet positioned centrally within the component 25.

The material of the component 25 is chosen in order to meet the requirements of formation by extrusion, and the dielectric and catalytic properties for the purpose
30 of reducing pollutants from internal combustion engine exhaust gases. The material is preferably a ferroelectric material such as barium titanate or calcium titanate which, for extrusion, will need to be prepared in powder form into which a binder material is
35 incorporated. Gamma alumina may serve as such a binder, but a preferred binder is a silicon and titanium

containing material for example in the form of a silica-
titania gel (which may be referred to as a silico-
titanate gel). The ferroelectric material may be mixed
with a dielectric material such as zirconia or titania,
5 or, for some applications, it may be appropriate to use
dielectric material alone or mixtures of dielectric
materials. Where titania is used, it is advantageous to
use the anatase phase or anatase phase in combination
with textured rutile in order to benefit from the
10 photocatalytic properties of the material in these forms.
Other materials such as alumina or a perovskite may be
incorporated for the catalytic properties which they
impart to the product matrix.

Claims

1. A component for use in a gas treatment device, which component comprises dielectric material having apertures
5 extending therethrough in a direction of gas flow through the component when in use, the apertures having a re-entrant configuration in cross-section and being such that there is interconnection through dielectric material of those regions of dielectric material which define
10 opposite sides of the narrowest part of the apertures as measured in at least one direction transverse to the said direction of gas flow, whereby when an electric potential is applied across the component in the said transverse direction, or one of the said transverse directions, the
15 voltage drop across the said narrowest part of the apertures is greater than the voltage drop thereacross would be if the aperture were filled with the dielectric material.
- 20 2. A component as claimed in Claim 1, wherein a pair of electrodes is positioned one on one side and the other on the other side of the component so as to be spaced apart from one another in the said transverse direction, or one of the said transverse directions.
- 25 3. A component as claimed in Claim 1, wherein the apertures are shaped to provide interconnection through dielectric material of those regions of dielectric material which define the opposite sides of the narrowest
30 part of the apertures as measured in two mutually orthogonal directions transverse to the said direction of gas flow, a first pair of electrodes is positioned one on one side and the other on the other side of the component so as to be spaced apart from one another in one said
35 transverse direction, and a second pair of electrodes is positioned one on one side and the other on the other

side of the component so as to be spaced apart from one another in the other, orthogonal, transverse direction.

4. A component as claimed in Claim 2 or Claim 3,
5 wherein the said apertures are such as to promote formation of a non-thermal plasma therein when the component is in use and an electric potential is applied across the electrode pair or pairs.

10 5. A component as claimed in any one of the preceding claims, wherein each aperture is shaped in cross-section to taper on both or all sides towards the said narrowest part of the aperture, thereby to encourage transfer of electrical discharge from the said narrowest part into
15 the tapered parts of the apertures.

6. A component as claimed in any one of the preceding claims, wherein the dielectric material is chosen to have in the presence of an electrical discharge a catalytic
20 action in the reduction of nitrogenous oxides.

7. A component as claimed in any one of the preceding claims, wherein the dielectric material is a barium titanate containing material.

25 8. A reactor for reducing pollution from exhaust emissions from an internal combustion engine, comprising a reactor chamber adapted to form part of an internal combustion engine exhaust system, the reactor chamber
30 including a component as claimed in any one of the preceding claims, through which component exhaust gases are constrained to pass.

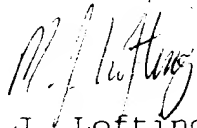
9. A component substantially as hereinbefore described
35 with reference to, and illustrated in, Figures 1 to 5 of the drawings filed herewith.

10. A reactor substantially as hereinbefore described with reference to, and illustrated in, Figure 5 of the drawings filed herewith.

5

15251 LgCm

10


M.J. Lofting
Chartered Patent Agent
Agent for the Applicants

Abstract

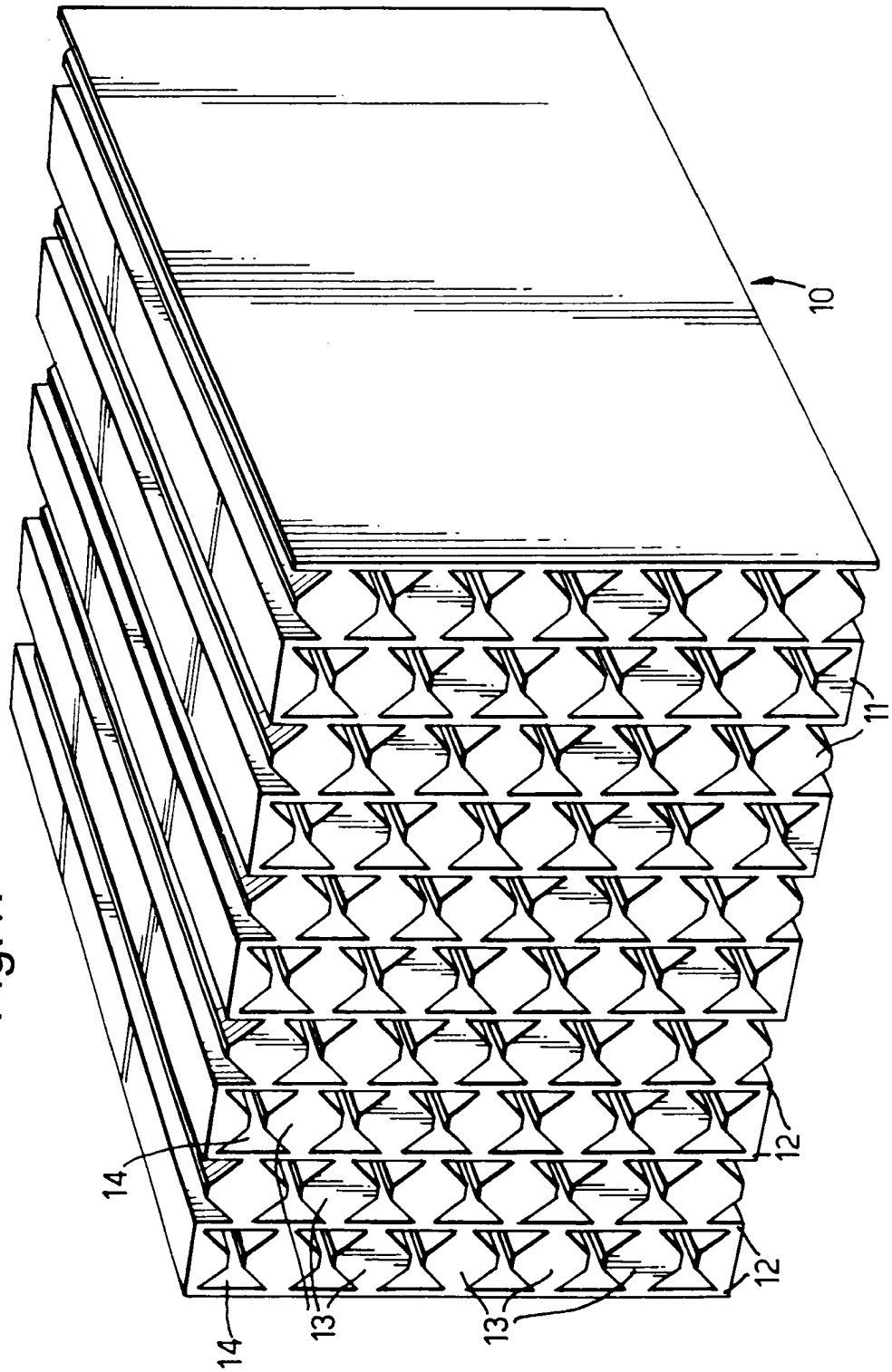
A component for gas treatment

5 A component of dielectric material for use in a gas
treatment device in which the gas is exposed to an
electric discharge, especially for the formation of a
non-thermal plasma. The component is formed with axially
extending apertures, shaped in cross section to
10 concentrate voltage drop derived from the charged
dielectric material in the region where the apertures are
narrowest.

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Fig.1.





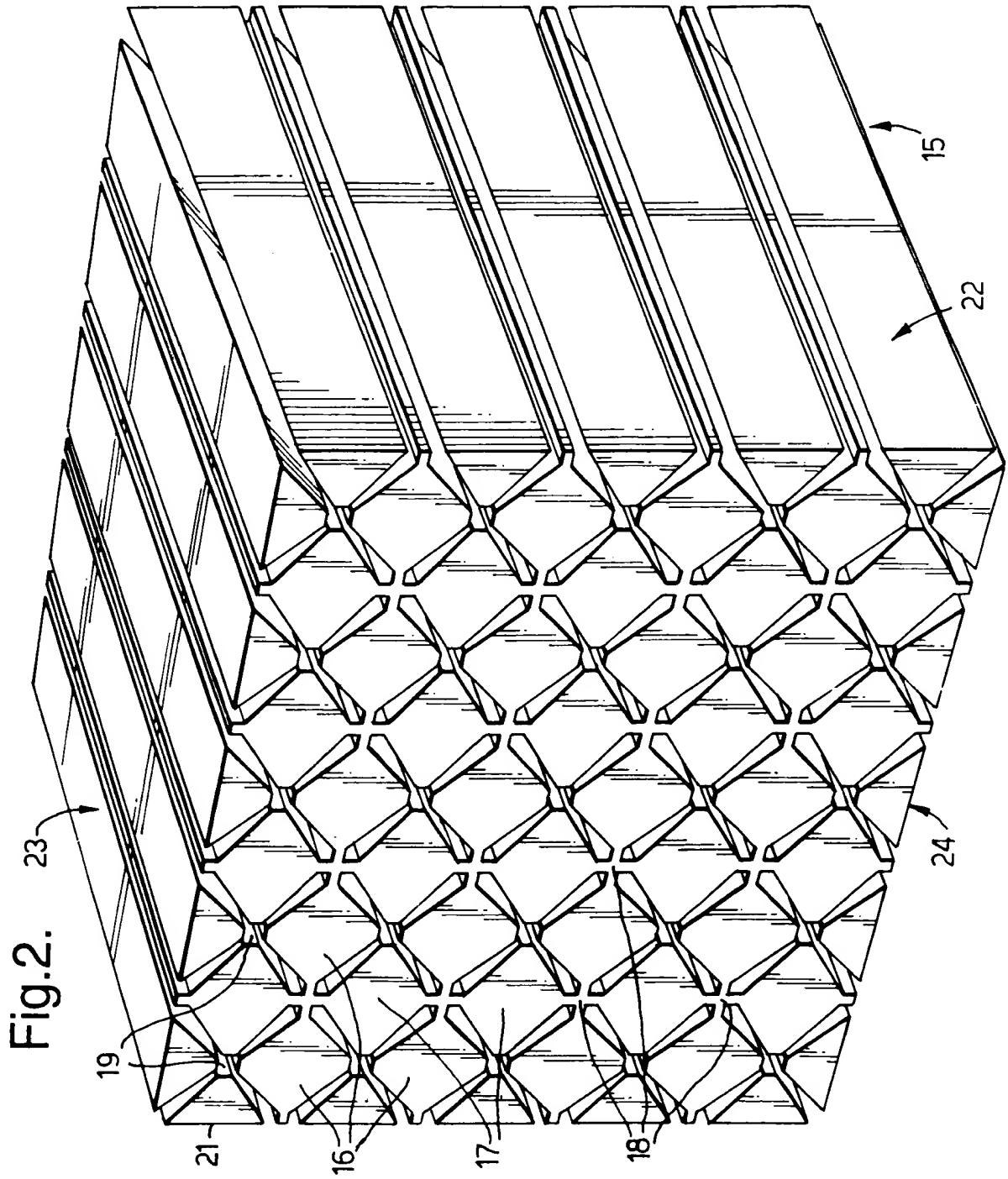




Fig.3.

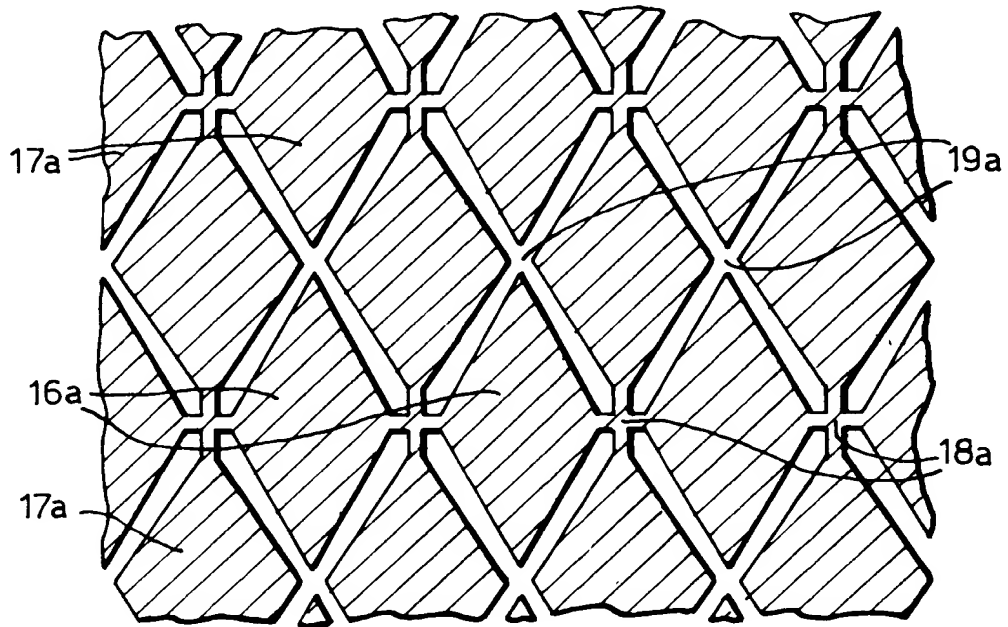


Fig.4.

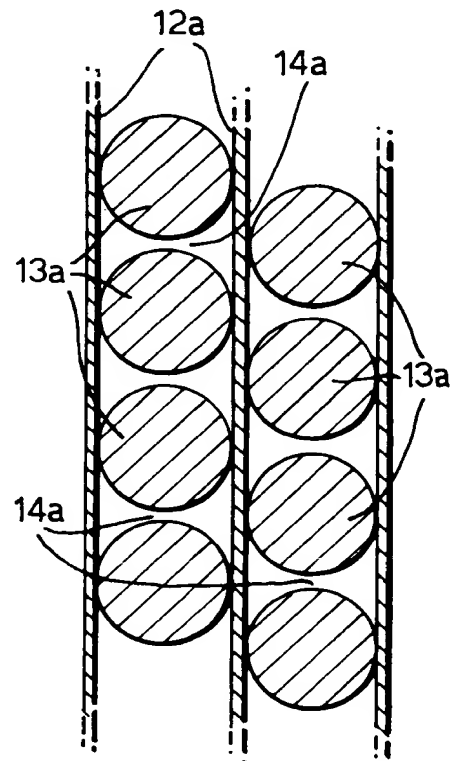
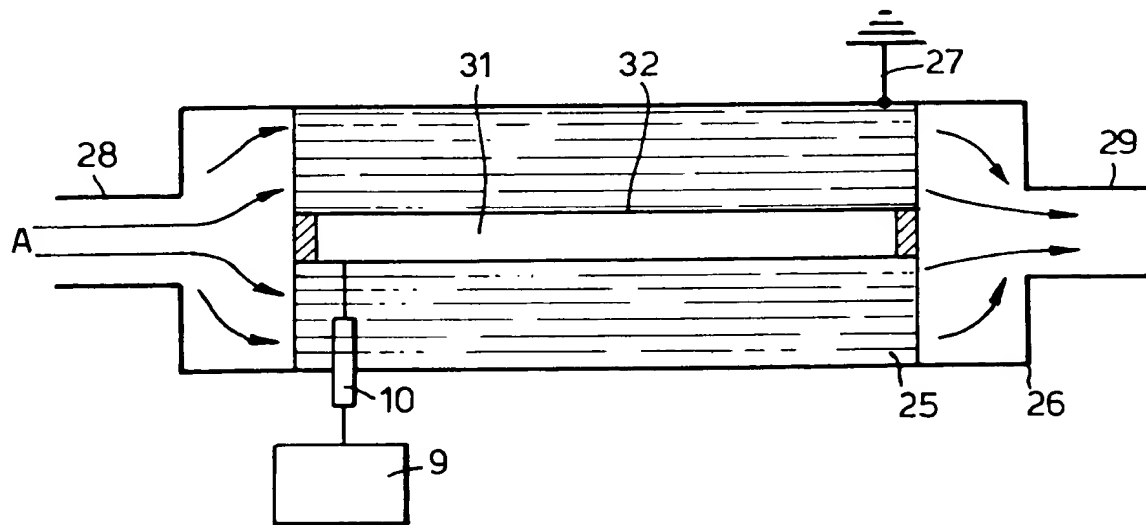




Fig.5.



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